

Ergonomics: The Study of Work



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What is ergonomics?

Ergonomics can be defined simply as the study of work. More specifically, ergonomics is the science of designing the job to fit the worker, rather than physically forcing the worker's body to fit the job.

Adapting tasks, work stations, tools, and equipment to fit the worker can help reduce physical stress on a worker's body and eliminate many potentially serious, disabling work-related musculoskeletal disorders (MSDs).

Ergonomics draws on a number of scientific disciplines, including physiology, biomechanics, psychology, anthropometry, industrial hygiene, and kinesiology.

Who needs to read this booklet?

You need to know about ergonomics if you are an employer or an employee in the manufacturing, construction, maritime, and agricultural industries and you or your employees' work activities and job conditions include:

- Repeating the same motion throughout your workday,
- Working in awkward or stationary positions,
- Lifting heavy or awkward items,
- Using excessive force to perform tasks, and
- Being exposed to excessive vibration or
- Extreme temperatures.

Why is ergonomics important?

Industries increasingly require higher production rates and advances in technology to remain competitive and stay in business. As a result, jobs today can involve:

- Frequent lifting, carrying, and pushing or pulling loads without help from other workers or devices;
- Increasing specialization that requires the worker to perform only one function or movement for a long period of time or day after day;
- Working more than 8 hours a day;
- Working at a quicker pace of work, such as faster assembly line speeds; and
- Having tighter grips when using tools.

These factors—especially if coupled with poor machine design, tool, and workplace design or the use of improper tools—create physical stress on workers' bodies, which can lead to injury.

A dramatic increase in MSDs began in the 1970s when these disorders increasingly appeared on companies' injury and illness logs. OSHA cited companies for hazardous workplace conditions that caused problems such as tendinitis, carpal tunnel syndrome, and back injuries.

The Bureau of Labor Statistics, an agency of the U.S. Department of Labor, recognizes MSDs as a serious workplace health hazard. These injuries now account for more than one-third of all lost—workday case.¹



Use tools that are right for the job.

Get a Grip!

Problem: Pharmaceutical technicians hand-tighten dozens of vaccine jug lids daily. If not adequately tightened, the jugs could leak and spoil products worth thousands of dollars. Testing revealed, however, that most operators are poor judges of cap torque—resulting in significant unwarranted hand and wrist stress. Operators also were marginally capable of using the proper torque required to tighten caps adequately.

Solution: The company purchased a dial torque wrench, made a special cap torque attachment, and trained the technicians to use the new equipment.

Cost: About \$8 per worker.

¹U.S. Department of Labor, Bureau of Labor Statistics, *News Release*, "Lost-worktime Injuries and Illnesses; Characteristics and Resulting Time Away from Work, 1998," April 20, 2000. Online at www.bls.gov.

If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting. Recognizing ergonomic risk factors in the workplace is an essential first step in correcting hazards and improving worker protection.

Ergonomists, industrial engineers, occupational safety and health professionals, and other trained individuals believe that reducing physical stress in the workplace could eliminate up to half of the serious injuries each year. Employers can learn to anticipate what might go wrong and alter tools and the work environment to make tasks safer for their workers.

What are MSDs?

MSDs, or musculoskeletal disorders, are injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) and nervous system. They can affect nearly all tissues, including the nerves and tendon sheaths, and most frequently involve the arms and back.

Occupational safety and health professionals have called these disorders a variety of names, including cumulative trauma disorders, repeated trauma, repetitive stress injuries, and occupational overexertion syndrome.

These painful and often disabling injuries generally develop gradually over weeks, months, and years. MSDs usually result from

exposure to multiple risk factors that can cause or exacerbate the disorders, not from a single event or trauma such as a fall, collision, or entanglement.

MSDs can cause a number of conditions, including pain, numbness, tingling, stiff joints, difficulty moving, muscle loss, and sometimes paralysis. Frequently, workers must lose time from work to recover; some never regain full health.

These disorders include carpal tunnel syndrome, tendinitis, sciatica, herniated discs, and low back pain. MSDs do not include injuries resulting from slips, trips, falls, or similar accidents.

What causes work-related MSDs?

Work-related MSDs occur when the physical capabilities of the worker do not match the physical requirements of the job. Prolonged exposure to ergonomic risk factors can cause damage a worker's body and lead to MSDs.

Conditions that are likely to cause MSD problems include the following:

- Exerting excessive force;
- Excessive repetition of movements that can irritate tendons and increase pressure on nerves;
- Awkward postures, or unsupported positions that stretch physical limits, can compress nerves and irritate tendons;
- Static postures, or positions that a worker must hold for long periods of time, can restrict blood flow and damage muscles;
- Motion, such as increased speed or acceleration when bending and twisting, can increase the amount of force exerted on the body;
- Compression, from grasping sharp edges like tool handles, can concentrate force on small areas of the body, reduce blood flow and nerve transmission, and damage tendons and tendon sheaths;
- Inadequate recovery time due to overtime, lack of breaks, and failure to vary tasks can leave insufficient time for tissue repair;

Parts of the Body Affected by MSDs

- | | |
|------------------|--------------------|
| • <i>Arms</i> | • <i>Back</i> |
| • <i>Hands</i> | • <i>Wrists</i> |
| • <i>Fingers</i> | • <i>Legs</i> |
| • <i>Neck</i> | • <i>Shoulders</i> |
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- Excessive vibration, usually from vibrating tools, can decrease blood flow, damage nerves, and contribute to muscle fatigue.
- Whole-body vibration, from driving trucks or operating subways, can affect skeletal muscles and cause low-back pain; and
- Working in cold temperatures can adversely affect a worker's coordination and manual dexterity and cause a worker to use more force than necessary to perform a task.

These risk factors, either alone or in combination, can subject workers' shoulders, arms, hands, wrists, backs, and legs to thousands of repetitive twisting, forceful, or flexing motions during a typical workday. To contribute to MSDs, however, these risk factors must be present for a sufficient duration, frequency, or magnitude.

Can non-work-related factors cause MSDs?

Yes. Risk factors not related to your job can cause or contribute to MSDs. These factors include:

- Physical conditioning;
- Medical conditions, such as obesity, diabetes, and arthritis;
- Pregnancy;
- Hobbies that are hand intensive or require manual handling. In these instances, however, because one can control the duration and exposures, hobbies usually are not primary risk factors; and
- Psychological or social workplace stress.



When lifting, maintain an upright position and avoid bending and twisting. Avoid lifting while sitting.

MSD Risk Factors

- **Force**
 - **Repetition**
 - **Awkward postures**
 - **Static postures**
 - **Quick motions**
 - **Compression or contact stress**
 - **Vibration**
 - **Cold temperatures**
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What types of work are most likely to pose ergonomic hazards?

MSDs affect workers in almost every occupation and industry in the nation and in workplaces of all sizes. The disorders occur most frequently in jobs that involve:

- Manual handling,
- Manufacturing and production,
- Heavy lifting,
- Twisting movements, and
- Long hours of working in awkward positions.

How do I know if I have an MSD?

You could have a work-related MSD if you experience any of the following:

- Numbness in your fingers,
- Numbness in your thighs,
- Difficulty moving your finger,
- Stiff joints, or
- Back pain.

What parts of the body are most affected by MSDs?

MSDs can affect nearly all tissues in the human body: the nerves, tendons, tendon sheaths, and muscles. The most frequently affected areas of the body are the arms and the back.

Tendon disorders such as tendinitis, tenosynovitis, De Quervain's disease, trigger finger, and carpal tunnel syndrome are the most common occupational MSDs associated with the arm.

Tendon disorders are very common and often occur at or near the joints where the tendons rub against other tendons, ligaments, or bones. The most frequently noted symptoms of tendon disorders are a dull aching sensation over the tendon, discomfort with specific movements, and tenderness to touch. Recovery is usually slow, and the condition may easily become chronic if the physical stresses causing the problem are not eliminated or reduced.

Another MSD that has received increased attention in recent years is **carpal tunnel syndrome, or CTS**, which affects the hands and wrists. CTS is the compression and entrapment of the median nerve where it passes through the wrist into the hand—in the carpal tunnel. The median nerve is the main nerve that extends down the arm to the hand and provides the sense of touch in the thumb, index finger, middle finger, and half of the fourth, or ring, finger.

When irritated, tendons housed inside the narrow carpal tunnel swell and press against the nearby median nerve. The pressure causes tingling, numbness, or severe pain in the wrist and hand—often felt while sleeping. The pressure also results in a lack of strength in the hand and an inability to make a fist, hold

objects, or perform other manual tasks. If the pressure continues, it can damage the nerve, causing permanent loss of sensation and even partial paralysis.

CTS develops in the hands and wrists from repetitive and forceful manual tasks performed without time to recover. Any worker whose job demands a lot of repetitive wrist, hand, and arm motion—not necessarily forceful—could develop CTS.

Another MSD that accounts for a significant loss of productivity and large compensation costs to industry is back injury. Workers cite back disorders most often, after the common cold and flu, as reasons for missing work.

The most common back problems are pulled or strained muscles, ligaments, and tendons. More serious disorders involve spinal discs. More than half the work force experience back pain at least once during a lifetime.

When repetitive pulling and straining injures back muscles or ligaments, the back muscles, discs, and ligaments can become scarred and weakened and lose their ability to support the back. This makes additional injuries more likely.

How much does it cost to prevent MSDs?

Many solutions to ergonomic problems in the workplace are simple and inexpensive. For

The High Cost of MSDs

- MSDs account for 34 percent of all lost-workday injuries and illnesses.
 - Employers report nearly 600,000 MSDs requiring time away from work every year.
 - MSDs account for \$1 of every \$3 spent for workers' compensation.
 - MSDs each year account for more than \$15 billion to \$20 billion in workers' compensation costs. Total direct costs add up to as much as \$50 billion annually.
 - On average, it takes workers 28 days to recover from carpal tunnel syndrome, longer than the time needed to recover from amputation or fractures.
 - Workers with severe injuries can face permanent disability that prevents them from returning to their jobs or handling simple, everyday tasks.
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example, awkward and uncomfortable positions can be eliminated by:

- Adjusting the height of working surfaces,
- Providing telephone headsets,
- Supplying anti-fatigue mats,
- Varying tasks,
- Providing short breaks,
- Reducing the weight and size of items workers must lift,
- Putting supplies and equipment within easy reach of the worker,
- Providing ergonomic chairs or stools, and
- Supplying the right tool for the job and the right handle for the worker.

Good ergonomics is good economics.

How can ergonomics help my workplace?

Providing a workplace free of ergonomic hazards can do the following:

- Lower injury rates as MSD incidences go down;
- Increase productivity by making jobs easier and more comfortable for workers;
- Improve product quality because fewer errors will be made when using automated processes that demand less physical effort;
- Reduce absences because workers will be less likely to take time off to recover from muscle soreness, fatigue, and MSD-related problems;
- Reduce turnover as new hires are more likely to find an ergonomically designed job within their physical capacity;
- Lower costs as workers' compensation and other payments for illness and replacement workers go down;
- Improve worker safety;
- Increase worker comfort;
- Reduce worker fatigue; and
- Improve worker morale.

Top Ten Occupations for MSDs

- Nurses aides, orderlies, and attendants
- Truck drivers
- Laborers not involved in construction work
- Assemblers
- Janitors and cleaners
- Registered nurses
- Stock handlers and baggers
- Construction laborers
- Cashiers
- Carpenters

Source: U.S. Department of Labor, Bureau of Labor Statistics, *News Release*, "Lost-worktime Injuries and Illnesses; Characteristics and Resulting Time Away from Work, 1998," April 20, 2000. Online at www.bls.gov.

What can I do to detect and prevent ergonomic hazards at my workplace?

MSDs are often easy to prevent. If you are an employer whose workplace poses ergonomic risk factors or whose workers report MSDs, you can address this problem by:

- Establishing an ergonomics program, and
- Providing and encouraging employees to participate in the ergonomics program and in decisions affecting their safety and health.

If you are an employee who is exposed to ergonomic risk factors, you should:

- Participate in your employer's ergonomics program; and
- Provide feedback to supervisors and employers through available channels, such as an established employee safety and health committee.

Effective ergonomic programs should include the following elements:

- Management commitment and employee participation,
- Job hazard analysis,
- Controlling ergonomic risk,
- MSD management, and
- Training and education.

Examples of Musculoskeletal Disorders

Body Parts Affected	Symptoms	Possible Causes	Workers Affected	Disease Name
thumbs	pain at the base of the thumbs	twisting and gripping	butchers, house-keepers, packers, seamstresses, cutters	De Quervain's disease
fingers	difficulty moving finger; snapping and jerking movements	repeatedly using the index fingers	meatpackers, poultry workers, carpenters, electronic assemblers	trigger finger
shoulders	pain, stiffness	working with the hands above the head	power press operators, welders, painters, assembly line workers	rotator cuff tendinitis
hands, wrists	pain, swelling	repetitive or forceful hand and wrist motions	core making, poultry processing, meatpacking	tenosynovitis
fingers, hands	numbness, tingling; ashen skin; loss of feeling and control	exposure to vibration	chain saw, pneumatic hammer, and gasoline-powered tool operators	Raynaud's syndrome (white finger)
fingers, wrists	tingling, numbness, severe pain; loss of strength, sensation in the thumbs, index, or middle or half of the ring fingers	repetitive and forceful manual tasks without time to recover	meat and poultry and garment workers, upholsterers, assemblers, VDT operators, cashiers	carpal tunnel syndrome
back	low back pain, shooting pain or numbness in the upper legs	whole body vibration	truck and bus drivers, tractor and subway operators; warehouse workers; nurses aides; grocery cashiers; baggage handlers	back disability

What is job hazard analysis?

Job hazard analysis identifies problem jobs and risk factors associated with them. This step helps employers determine what jobs and work stations are the source of the greatest problems. The most effective worksite analyses include all jobs, operations, and work activities where there are ergonomic risk factors, regardless of whether the employer's medical records indicate that workers have developed MSDs.

A thorough job analysis is important to successfully prevent or reduce the various MSD hazards at a work site. Workers exposed to ergonomic risk factors may develop a variety of symptoms. Moreover, a combination of factors in a single job or work station may cause MSDs. For example, research has shown that various symptoms among VDT operators result from problems in equipment, work stations, the office environment, and job design, or a combination of these. In addition, VDT operators experience not just one simple MSD, but often eyestrain, headaches, and excessive fatigue as well as neck, back and muscle pain, and stress. A comprehensive analysis of the worksite will identify the interplay of how various ergonomic risk factors affect workers.



Video display terminals (VDTs) should be equipped with adjustable and detachable keyboards, display screens that tilt up and down, brightness and contrast controls, and flexible copy holders that reduce the distance between the screen and the source material.

CTS and Repetitive Motion

The meatpacking industry is one of the most hazardous industries in the United States because workers can make as many as several thousand repetitive motions per day in assembly line processes, such as deboning meats, with no variation in motion. The motions place physical stress and strain on the wrists and hands, resulting in CTS.

In manufacturing, garment makers, who often perform fast-paced piecework operations involving excessive repetitive tasks, increase their risk of developing CTS. Garment industry jobs often require workers to push large amounts of materials through machinery while sitting on unadjustable metal stools. Workers doing these jobs can sustain disabling wrist, back, and leg injuries.

How do I control ergonomic risk factors?

Employers can prevent MSD hazards by properly designing the job or work station and selecting the appropriate tools or equipment for that job. Based on information from the job analysis, an employer can establish procedures to correct or control risk factors by using:

- Appropriate engineering controls, such as work station, tool, and equipment design or redesign;
- Work practices, such as proper lifting techniques and keeping work areas clean;
- Administrative controls, such as worker rotation, more task variety, and increased rest breaks, and if necessary;
- Personal protective equipment, such as knee pads, vibration gloves, and similar devices.

The National Institute for Occupational Safety and Health recommends using the following guidelines in jobs requiring manual handling:

- Minimize the distance between the load and the body.
- Lift loads from knuckle height.
- Keep the travel distance for the lift to less than 10 feet.
- Minimize twisting.
- Provide good handles for grasping loads.

It is also important that work tools and equipment be ergonomically designed. Most hand tools are designed for only occasional use, not for repetitive use over prolonged periods. When acquiring tools for regular use in an industrial setting, an employer should consider the following ergonomic features:

- Tools should be light-weight and handles designed to allow a relaxed grip so the wrists can remain straight.
- Tools should be designed for use with either hand and be of various sizes so they are appropriate for all workers.
- Tool handles should be shaped so that they contact the largest possible surface of the inner hand and fingers. Avoid tool handles with sharp edges and corners.
- Use power tools to reduce the amount of human force and repetition required.
- Purchase low-vibration tools to reduce tool vibration, and, if necessary, fit absorbent rubber sleeves over the tool handle.

Maintenance of tools and equipment also is essential in preventing or reducing ergonomic hazards. Keep tools sharp and maintain them according to the manufacturer's specifications. Proper maintenance also can help reduce vibration resulting from prolonged equipment operation.

What comprises MSD management?

MSD management is another important element of an effective ergonomics program.

An Uplifting Solution

Problem: At a glass ceramic cooktop plant, workers manually lift uncut plates of glass onto a waist-high conveyor belt, where it is then stacked vertically on a nearby L-shaped holder. A forklift handles the strapped holder carrying the glass. The holder, however, presents the glass at knee-height, making workers bend each time to pick up the glass.

Solution: The workers devised a stand made from a wooden shipping crate and placed it beneath the L-holder to raise the glass to waist height.

Cost: A little labor.

Proper MSD management focuses on early identification and evaluation of signs and symptoms of MSDs and helps eliminate or reduce the risk of developing MSDs.

Employers should include the following elements in any MSD management program:

- Injury and illness recordkeeping;
- Early recognition and reporting of MSD symptoms;
- Systematic evaluation and referral to a qualified health care provider;
- Conservative treatment, such as restricted duty jobs, when necessary;
- Conservative return to work;
- Systematic monitoring, including periodic workplace walkthroughs;
- Adequate staffing and facilities where employers provide on-site evaluation;
- Employee training and education;-
- Access to health care providers for each work shift; and
- No barriers to early reporting.

What type of training and education program do I need?

Training programs will go a long way toward increasing safety awareness among managers and supervisors, designers, buyers, mechanics, and workers who perform the jobs. Training and education ensure that employers sufficiently inform workers about ergonomic risk factors at their worksites so they are better able to participate actively in their own protection. Suggestions and input from workers aware of ergonomic risk factors can be very helpful in designing improved workplaces to reduce MSD hazards.

A good ergonomics training program will teach employees how to properly use equipment, tools, and machine controls as well as the correct way to perform job tasks.

For example, employers should encourage work methods that allow workers to keep their joints in a neutral position (wrists straight and elbows bent at a right angle) while using tools requiring manual force to prevent excessive force on joints and tendons. Employers also should tell workers to avoid all side-to-side twisting and quick motions of their wrists and to keep their hands in line with their forearms while using tools or operating equipment. Employers should provide the appropriate controls or tools, as necessary, to reduce or eliminate awkward positions.

To minimize or prevent back disorders, employers should teach workers to avoid long reaches, maintain neutral postures, and use proper lifting techniques. Using correct posture is important whether an employee is

A Perfect Fit

Problem: Employees in a poultry processing plant complained that ill-fitting protective gloves did not provide adequate protection.

Solution: The poultry processing company bought workers protective gloves from several manufacturers to provide a wide range of sizes for better fit.

Cost: Negligible.

sitting, standing, pulling, pushing, lifting, or using tools or equipment. Training workers in general lifting techniques also can help reduce the strain leading to back disorders. For example, employees should use their leg muscles and bend their knees to pick up and lower heavy loads. Providing appropriate equipment, such as conveyors or carts, lift tables and list assists, can also reduce load weight, minimizing incorrect lifting and potential injury.

How do I begin an ergonomics program at my workplace?

If you are an employer who has identified the need for an ergonomics program at your worksite, start by planning the program and the goals, and then put it into action.

Arm Them with Knowledge!

Problem: Employees in many different offices experience pain from their daily tasks.

Solution: Train workers to properly use the adjustments already provided in their chairs, computer monitors, and furniture systems. Changes in the placement of telephones, printers, and in-boxes can lead to better working posture. In addition, training and encouraging employees to take micro-breaks help overused parts of the body rest and recuperate.

Cost: Nothing.

Really Turning It Around...

Problem: Workers pack items into rectangular boxes, positioned so they must reach repeatedly across the long axis of the boxes, exposing their backs, shoulders, and arms to physical stress.

Solution: Rotating the boxes allows workers to reach across the shorter axis of the box, reducing the length of reach and the risk of injury.

Cost: Nothing.

OSHA publishes booklets and fact sheets detailing agency policy and regulations. Publications are listed on OSHA's website, or you also may contact the OSHA Publications Office, P.O. Box 37535, Washington, DC 20012-7535, (202) 693-1888.

A wide range of publications on ergonomics are available from the National Institute for Occupational Safety and Health by calling 1-800-35-NIOSH, or through the link on OSHA's website.

Some OSHA-approved state plans also have materials available on ergonomics, such as CAL-OSHA's, *Easy Ergonomics: A Practical Approach for Improving the Workplace*, at www.dir.ca.gov/tite8/5110.html.

You also may want to contact the ergonomics coordinator at the nearest OSHA Regional Office listed elsewhere in this brochure for further information and assistance. You can also find out about programs such as OSHA's a free consultation program, which can help you find out about potential hazards at your worksite, improve your occupational safety and health management systems, or qualify for a 1-year exemption from routine OSHA inspections. If you are in a state that operates its own OSHA-approved safety and health plan, please contact your state plan office. State plans and consultation programs are listed on OSHA's website under **Outreach**.

How can I find out more about ergonomics?

For more information about ergonomics, contact the ergonomics coordinator at your OSHA Regional Office, visit the Ergonomics Page on OSHA's website at www.osha.gov, or call 1 (800) 321-OSHA.



Move work surfaces closer to the body and to a comfortable height.

Glossary

anthropometry - The study of human body measurements. Used in developing design standards and requirements for manufactured products to ensure they are suitable for the intended audience.

biomechanics - A scientific and engineering field that explains the characteristics of biological system—the human body—in mechanical terms.

carpal tunnel syndrome - The compression and entrapment of the median nerve where it passes through the wrist into the hand—in the carpal tunnel. The median nerve is the main nerve that extends down the arm to the hand and provides the sense of touch in the thumb, index finger, middle finger, and half of the fourth, or ring, finger.

De Quervain's disease - Inflammation of the tendon sheath of the thumb attributed to excessive friction between two thumb tendons and their common sheath. Usually caused by twisting and forceful gripping motions with the hands.

industrial hygiene - The science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause worker injuries and illnesses.

kinesiology - Study of the principles of mechanics and anatomy in relation to human movement.

musculoskeletal disorders - Injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) and nervous system.

Raynaud's syndrome, or white finger - Blood vessels of the hand are damaged from repeated exposure to vibration long period of time. The skin and muscles do not get the necessary oxygen from the blood and eventually die. Symptoms include intermittent numbness and tingling in the fingers; pale, ashen, and cold skin; eventual loss of sensation and control in the hands and fingers.

tendinitis - Tendon inflammation occurring when a muscle or tendon is repeatedly tensed from overuse or unaccustomed use of the wrist and shoulder.

tenosynovitis - Inflammation or injury to the synovial sheath surrounding the tendon. Usually results from repetition excessive repetitive motion.

trigger finger - A tendon disorder that occurs when there is a groove in the flexing tendon of the finger. If the tendon becomes locked in the sheath, attempts to move the finger cause snapping and jerking movements. Usually associated with using tools that have handles with hard or sharp edges.

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*These states and territories operate their own OSHA-approved job safety and health programs. Connecticut and New York plans cover public employees only. States with approved programs must have a standard identical to, or at least as effective as, OSHA federal standards. For more information on state plans, visit OSHA's website at www.osha.gov.